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## **Broadband deployment and the bandwagon effect in the UK**

*Advait Deshpande*

### **Abstract**

#### **Purpose**

This paper looks at the extent to which the bandwagon effect played a part in Digital Subscriber Line (DSL) broadband adoption combined with the regulatory measures, the slowdown in the cable industry and the changes within the telecommunications industry in the United Kingdom (UK). The dynamics of broadband deployment, broadband adoption against a real-world supply-demand equation and the factors that influenced the outcome in the UK are examined in detail.

#### **Design/methodology/approach**

This paper combines historic facts and socio-economic analysis done from archival research and interview material to examine the outcome in which the less-heralded copper DSL technology outpaced cable broadband adoption. The analysis delves into the influence of the bandwagon effect and the two types of outcome associated with it i.e. network externalities and the complementary bandwagon effects.

### **Findings**

The paper argues that the deployment of broadband technologies in the UK has not taken place solely on the merits of the technology or factors such as speed, end-user demand and costs. A combination of factors related to regulatory decisions, status of industry finances, commercial expediency, short-term technical benefits and the bandwagon effect are argued to be at work.

## **Originality/value**

The paper is useful for historians, policy makers, regulators and communications industry analysts given its focus on broadband deployment in the UK in correlation to the bandwagon economics.

**Keywords:** *British Telecom, Broadband Networks, Telecommunications industry, Regulation, The bandwagon effect, United Kingdom*

## Introduction

As of 2001, the broadband market in the United Kingdom (UK) was in its nascent state. In the early to late-1990s, the term "broadband" mostly referred to broadcast television and video content that was carried by cable networks (hence the mention of broadband cable in some of the literature. See (Fox, 1990)). Telecom industry initiatives like Integrated Service Digital Network (ISDN) and Broadband ISDN (B-ISDN) were in part aimed at bringing such high-bandwidth, video capabilities to the telecom networks (Kano et al., 1991). Video-on-demand (VOD) and pay-per-view were seen as the premium services that would provide additional revenue-earning opportunities in an increasingly competitive market (see (BT, 1994b; 1998b) for BT's forays into the on-demand and broadcasting services; Young, 2012). In the mid to late 1990s, with the growth in the narrowband (i.e. dial-up) subscriptions for Internet access, telecom operators began to consider the alternatives to delivering high-speed data to the end-users.

In this context, British Telecom (BT) conducted Digital Subscriber Line (DSL) trials in 1997-1998 to decide whether copper-based DSL was a good enough conduit for delivering Internet access. BT however remained uncertain about whether a market existed that would deliver a return on the investment for enabling the existing copper networks to deliver DSL connectivity. This question of return on investment (ROI) and what kind of services such high speed broadband [1] would deliver was also critical to the cable industry. The UK cable industry had consolidated into two major players, NTL (originally National Transcommunications Limited) and Telewest. Both cable operators needed an additional source of revenue to compete with British Sky Broadcasting (BSkyB) Corp., the premier satellite broadcasting services provider in the UK, on the content front. On the telephony front, NTL and Telewest had to contend with the significant market power (SMP) of BT. In addition, the extent to which such broadband connectivity could be monetised, and the kind of premium services it would enable, was unclear. With close to 10 million end-users already using dial-up Internet access (Office of Telecommunications i.e. Oftel, 2001a), the extent and speed with which such end-users could be switched to a broadband connection that cost significantly more was also difficult to ascertain.

All these factors created an uncertain environment for telecom operators such as BT and

the cable operators such as NTL and Telewest in relation to rolling out broadband. This paper discusses the eventual outcome in relation to the deployment of copper-based DSL and coaxial cable broadband during the period from 2001 to the present day. Such deployments are considered in the context of the supply-and-demand dynamics for broadband technologies and the role of bandwagon effect on their adoption. The paper uses archival research and interview material to argue that in the deployment and adoption of broadband technologies, technical merits or economic feasibility were not the only factors that influenced the outcome. This argument is crucial since the success or failure of technologies is often attributed to benefits relative to their price or technical merits. The paper examines a range of factors associated with regulatory policy, industry circumstances and the bandwagon economics [2] to present a detailed analysis of the events.

### **Bandwagon economics and the supply-demand equation**

The bandwagon effect in microeconomics refers to the situation where the benefits of a product or service derived by an end-user increase relative to the number of end-users who use the product or service (Leibenstein, 1950). Such an accumulation of end-users creates a strong demand for the product or service and influences the supply-side significantly. The bandwagon effect is one of three complementary effects in the theory of demand along with the Snob effect (which focuses on the exclusivity of a product/service driving the demand) and the Veblen effect (which focuses on the increase in the pricing of a product/service driving the demand) (Leibenstein, 1950).

The bandwagon effect is manifested in two types of outcomes that influence the accumulation of end-users. The first type of bandwagon effect is the network externalities. Due to the network externalities, the benefits available to end-users increase or multiply because of the additional end-users who use or sign up for the product or service (See (Rohlf, 1974) which specifically discusses interdependent demand in the communications industry and its relation to an increase in the number of end-users). The network externalities are associated with the demand-side equation of the bandwagon effect. The second type of bandwagon effect is known as the complementary bandwagon effects. As a result of the complementary bandwagon effects, the supply of the product or service increases in response to the cumulative demand for competitively priced complementary products or services created by the

bandwagon effect (Haring et al, 2002; Rohlfs, 2001). In contrast to the network externalities, the complementary bandwagon effects are associated with the supply-side of the bandwagon effect.

Part of the argument presented by the theory of demand and the bandwagon effect is that the end-user demand is not just driven by the pricing of products or services but also by the value and quality. The events throughout the 2000s show that the technical merits and pricing are just one of the factors that influenced the end-user demand and the deployment of broadband technologies. For a better understanding of the outcome, the factors that influenced the supply-side of the broadband deployment also need to be considered. To understand the influence of the bandwagon effect, the next two sections look at the factors that drove the rollout of broadband connections based on coaxial cable and copper DSL technologies respectively. This discussion is then followed by an analysis of the socio-political and regulatory factors that influenced such rollouts.

## **Coaxial cable**

Following significant consolidation in the cable industry in the late 1990s, there were two major players left in the UK - NTL and Telewest. Despite the consolidation however, the coaxial cable network reached only 50% of UK households and businesses (OfTel, 2002a). On the other hand, the copper-based Public Switched Telephone Network (i.e. PSTN used by telecom operators such as BT) had a near universal reach to the UK households and businesses. Although cable operators could carry BSkyB content through a wholesale agreement, and they were allowed to carry telephone services, they still sought a product that would be their unique selling proposition. With the narrowband market approaching saturation (OfTel, 2001a) [3], the demand for higher speeds and higher bandwidths was visible and suggested that a consumer market existed for broadband connectivity. The problem faced by the cable industry was of being unable to decide the extent of the rollout for such connectivity and its pricing.

Compared to the telecom operators, the cable industry had one critical advantage when it came to broadband rollouts: its network was built on coaxial cable and Hybrid-Fibre Coax (HFC) technologies. In addition to being able to carry high-speed and high-bandwidth data, the cable networks were also superior to the copper PSTN in suffering far less from signal attenuation. A copper DSL broadband connection would decrease in

bandwidth and speed as the distance of the end-user premises from the local exchange increased. The cable networks were not affected by this limitation and could deliver nearly the same bandwidth over the entire distance. In subsequent years, as the cable industry worked to minimise its legacy problems, such as fragmentation of standards, systems and services, the inherent technical merit of its network allowed the cable operators to position themselves as providers of a combined bundle of telephony, television and broadband services (Taylor, 2012). Effectively, on the back of the HFC investments made in the 1990s and the Data Over Cable Service Interface Specification (DOCSIS) standards, cable operators could offer a superior, vertically integrated broadband product. The telecom operators, in turn, saw an opportunity to counter the cable operators' broadband proposition by delivering next generation DSL capabilities. The intervention by the regulatory bodies for the UK telecommunications sector (OfTel, and later the Office of Communications i.e. Ofcom) proved crucial at this juncture. From 2004 onwards, Ofcom re-worked its unbundling strategy (Clarkson, 2012). The functional separation of BT (described below), achieved in 2006, further fuelled the competition for copper DSL as the next section explores.

## **Copper DSL**

Compared to coaxial cable/HFC, copper DSL was mostly an unheralded technology. Although the DSL technology and some of its modulation techniques had been conceptualised as early as 1993 [4] (Cioffi, 2011a), it wasn't until 1997-98 that BT considered DSL for delivering broadband Internet connectivity (BT, 1998a). With speeds of 2 Mbit/s that dropped progressively beyond the initial 3 km length of the copper wire from the end-user premises, DSL was perceived to be a short-term solution (Starr et al, 1999). As a result, DSL was expected to tide over the limitations of narrowband connectivity until the eventual deployment of optical fibre.

Despite its limitations however, DSL had other advantages. Not only would copper DSL allow the telecom operators to make the most of their existing copper assets (Cioffi, 2011b; Shearman, 2012), the technology also enabled efficient utilisation of the bandwidths that copper could deliver. At the time of its conception in 1993-94, DSL was considered by incumbent telecom operators as a technology that would allow VOD services to be run on copper networks (See Cioffi, 2011a). Given the asymmetric nature of digital applications (covering video and data), Joseph Lechleider, one of the architects

of the DSL concept, suggested using more bandwidth downstream than upstream, a concept that was equally applicable to the nature of Internet traffic (Cioffi, 2011a). Such Asymmetric DSL (ADSL) meant that a copper pair could be effectively used to deliver speeds of 2 Mbit/s downstream and 128 kbit/s upstream (Starr et al., 1999), a capacity previously inconceivable in relation to copper. However, despite the subsequent improvements that allowed it to carry higher speeds over longer distances, the DSL broadband would still remain comparably slower than cable broadband on most occasions.

An advantage of DSL was its relative ease in delivering broadband to existing telecommunications end-users. When the local exchange was equipped with DSL capability, the end-user's premise only needed to be fitted with a modem and a micro-filter device (more specifically an ADSL splitter) that would separate the data and voice traffic and deliver the promised broadband connectivity (Valdar, 2006). The self-installation of such equipment by the end-users avoided the need for an engineer to visit the end-user premises and further lowered the cost of deployment for a telecom operator such as BT (Starr et al, 1999). When the prevailing economic and regulatory environment is considered, all these factors could be seen to have added up in favour of copper DSL technology despite its limited technical merit. These prevalent economic and regulatory factors are discussed in the next three sections.

### **Narrowband and the network congestion**

Up to 2000-2001, most of the Internet connectivity in the UK was provided by narrowband connections based on the PSTN. Several Internet Service Providers (ISPs) used an unmetered wholesale access product from BT called Flat Rate Internet Access Call Origination (FRIACO). As a result of FRIACO, fully unmetered retail packages (giving unlimited data usage and no call costs) were available for £12.99 - £14.99 a month (Ofel, 2001a). With 10 million narrowband end-users and the Internet traffic doubling every 10 months, the end-user experience was soon expected to be plagued by network congestion and significantly lower speeds as a consequence (O'Reilly, 2005; 2011). Such congestion pointed to a need to upgrade the existing copper-based technology and to better manage the increasing demands on BT's switches in the core network. The resolution depended not only on ascertaining the end-user demand but also on determining whether the end-users would be willing to pay the additional cost of



upgrading to broadband.

By this time, Oftel needed to align its policies with the European Union (EU) regulatory framework. Oftel also needed to achieve the goals set by the Labour government for Internet access and speeds [5] (Oftel, 2001b). As a consequence, Oftel considered measures such as local loop unbundling (LLU). With LLU, Oftel aimed to lower consumer prices, increase competition in the access network and infuse additional investments in the network infrastructure (Oftel, 1998). Part of the reason to push unbundling was to accelerate the deployment of broadband technologies by telecom operators, particularly BT (Oftel, 1998). Despite the fact that BT had conducted its most recent trials of copper-based DSL technology in 1997-98, uncertainty prevailed in the fixed-line market about not just the potential of DSL but also the returns on such an investment due to demand constraints (Oftel, 2001b; Haring et al, 2002; Verwaayen, 2012).

An important impetus to BT's decision making in relation to a DSL broadband rollout was the competitive threat from the cable industry which, with the consolidation into NTL and Telewest, had the potential for scale it lacked before. With regulatory price caps on its telephony revenue, BT also needed to create new revenue streams (Feasey, 2012). Despite the technical superiority of the cable network, one of its main limitations was that it had at the most 50% market reach and broadband could not be delivered to about 5% of these premises due to technical limitations (Oftel, 2002a). Effectively only 45% of the UK households and businesses could get cable broadband (Oftel, 2002a). In addition, the cable network suffered from significant fragmentation in terms of the network equipment, implementation of standards, end-user equipment, information systems and end-user services issues (Taylor, 2012). These problems were due to the original nature of cable franchise allocation in the late 1980s and 1990s as a result of which more than 100 cable franchise areas existed in the UK [6] (ITC, 1997). The presence of such disparate franchise structure led to the implementation of incompatible standards and equipment in these franchises (Taylor, 2012; Cluny, 2012). Most importantly such fragmentation meant that until the consolidation, the cable industry lacked the capability to rapidly build the economies of scale in order to compete with the telecom operators on pricing and upgrading the cable plants for delivering broadband. Some of these difficulties were exacerbated by the events related to the 2000-2001 dotcom crash, the subsequent recession and the changes in the United

States of America (USA) market (Feasey, 2012).

### **Dotcom crash, recession and bankruptcy**

A significant amount of investment in the UK cable industry throughout the late 1980s and 1990s was made by cable and telecom companies such as Comcast, Bell Cablemedia, Nynex and Videotron which had parent operations in the USA and Canada (ITC, 1997). Some of these companies looked for opportunities in the UK, partly because of the regulatory restrictions in the USA which limited investment opportunities. Since the cable industry in the UK was significantly less regulated than the USA, the UK was an attractive investment destination (Feasey, 2012). By the mid to late 1990s, there were ten cable companies operating in the UK, with more coming later (ITC, 1997). In addition, not all of these operators functioned in contiguous franchise areas (Cluny, 2012). All of this resulted in the significantly fragmented nature of cable operations in the UK. With the dotcom boom in the late 1990s and the subsequent dotcom crash, some of these companies were severely stretched financially (Curwen, 2002). In the subsequent years, as the regulatory restrictions in the USA eased, the North American cable and telecom companies largely exited the UK market either by systematic withdrawal or by selling their UK cable assets completely (Feasey, 2012; Smale, 2012; Taylor, 2012). An example is Cable & Wireless Communications which was created in 1997 with the merger of Mercury Communications and the UK cable operations of Nynex, Bell Cablemedia and Videotron (C&W, 1997; ITC, 1997). These events meant that although the UK cable industry could finally operate on a regional scale it had previously been incapable of, it no longer had the financial wherewithal to do so. The outcome of this financial crunch, combined with the costs of integrating the fragmented UK cable operations and the pressure from BSkyB and BT, was the near-collapse of the UK cable industry (Smale, 2012; Taylor, 2012). The two companies that had emerged in the consolidation, NTL and Telewest, went into administration in 2002 (Curwen, 2002; 2003) and had to undergo financial restructuring. Consequently, the UK cable industry did not have the financial strength to push for cable broadband in the nascent stage of the broadband market. As a result, despite the technical advantages of cable broadband, its deployment was significantly constrained.

Similar financial constraints also affected BT which had made large investments outside the UK throughout the 1990s. Most of these investments were made on the back of its

annual profits to the tune of £1-2 bn in the UK in the early 1990s [7] (BT, 1992; 1993b; 1994a). Since BT was prohibited from carrying television content on its main network until 1999, it had continually argued an inability to invest in deploying optical fibre in its UK access network, citing lack of opportunities to recoup its costs (BT, 1993a). In addition, although BT had retained SMP in a number of market segments, it faced increasing competition with the introduction of mobile telephony. Another factor responsible for the increased competition was the disbanding of BT's duopoly with Mercury Communications and the resultant full liberalisation of the UK telecommunications industry in 1992. Some of BT's major investments during this period were the costly 3G licence in the UK (£4.03 billion in 2000. See BT, 2000, p. 14), 3G licence in Germany (for Viag Interkcom purchased at the cost £5.13 bn in 2000-2001. See BT, 2001b, p. 14), Netherlands (BT paid £1.2bn to acquire Telfort in April 2000 and paid £267 million for a Dutch 3G licence. See BT, 2001b, p. 14) and France (BT acquired a 26% stake in Cegetel in September 1996 for £1 billion. See BT, 1997, p. 19). This meant a significant amount of BT's financial resources were tied up not just in the UK but outside the UK as well. Although BT made tidy sums of profit on some of these ventures [8], by 1999 BT losses from its ventures outside UK grew to £342 mn (BT, 1999, p. 31). By March 2000, BT's net debt grew to £8,700 million with an increase of £7,747 million in the financial year 1999-2000 (BT, 2000, p. 36). In the financial year 2000-2001, the net debt rose to £27.9 billion and BT had to take measures to reduce its debt (BT, 2001a, p. 2). Part of the subsequent restructuring led to demerger and eventual sell off of BT's mobile services business in Europe [9]. Although the £17.7bn generated enabled BT to reduce its debt significantly, BT would miss out on the higher Average Revenue Per User (ARPU) earned by mobility companies over the next decade (Crowcroft, 2012). BT would also have to endure low revenue streams in the existing saturated fixed-line telephony market in which its prices were capped (Feasey, 2012). The outcome was that BT not only lacked the justification for investment into optical fibre but also that DSL was the most expedient option in economic and commercial terms for delivering broadband. The drive for DSL deployment was further spurred by the regulatory measures adopted by Oftel/Ofcom and some of the key decisions made by BT as the next section examines in detail.

## **Regulation, further consolidation and unbundling**

Aside from the financial problems faced by the cable companies, the focus of their

activities after the consolidation remained on reducing the problems of fragmentation, incompatible systems and standardising equipment across regions (Cluny, 2012). The cable industry was unsure of the potential of broadband and the extent to which Internet-based premium services could be monetised (Cluny, 2012). As a result, NTL and Telewest chose to focus on improving their operations to achieve better economies of scale. In March 2006, the operations of NTL and Telewest were consolidated to create "NTL:Telewest". A further merger with Virgin Mobile in July 2006 led to the creation of a rebranded, single entity - "Virgin Media". In effect, Virgin Media became the first UK company to offer a quadruple play of services i.e. television, broadband, fixed and mobile telephony (Smale, 2012).

During this period of further consolidation in the UK cable industry, the DSL rollout had given BT and the other telecom operators wider reach in the UK for their broadband products by 2006 [10]. Although the process of unbundling had been initiated in 1999, very few operators showed any interest in unbundling until the mid-2000s (Ofcom, 2004). This was partly due to the unfavourable economics of unbundling for the Other Line Operators (OLOs) (Ofcom, 1998; Sandbach and Durnell, 2002). The OLOs, as a result, had mostly relied on the wholesale line rental (WLR) services to rent the capacity and DSL connectivity from BT instead of building their own routes into the BT exchanges. By the mid-2000s, the market was deemed to be over-reliant on BT's wholesale products (Ofcom, 2004; 2005). The increased end-user demand suggested that the deployment of next generation DSL equipment in the form of ADSL2 and ADSL2+ technologies was needed. This led to an increased interest in unbundling and spurred an intervention on the part of Ofcom (see Stern (2004) for changes in the regulatory approach with the transition from Oftel to Ofcom). Because of the limited success of the earlier unbundling initiative, Ofcom's focus this time centred on enabling equal access and ensuring that the OLOs' broadband products were not disadvantaged by BT's wholesale pricing (Ofcom, 2004; 2005; 2006).

Another aspect of the increased DSL rollout was that in 2002, BT had set an ambitious agenda for rolling out DSL connectivity to the exchanges and the end-users' premises. This agenda was set in motion by BT's then Chief Executive Ben Verwaayen. He also devised specific time-bound targets for BT to achieve these goals. Combined with the take up of wholesale connectivity, the aim was to deliver five million broadband connections in the UK by 2006 (BT, 2002, p. 13). This rollout relied on the legacy copper

infrastructure which was mostly owned by BT. As a result, BT held SMP in the wholesale broadband market segment and led the retail broadband segment [11] (Ofcom, 2006). In consequence Ofcom decided to intervene in order to inject more competition into the broadband market.

With the possibility of Ofcom taking BT to the Competition Commission (CC) and recommending a structural break up of BT, an agreement was reached between BT and Ofcom for functional separation of BT operations (BT, 2006; Ofcom, 2006; See Stern, 2004 for discussion on the policy of structural separation in the UK regulatory regime). Under this agreement, BT would create a separate division named "Openreach" for its network operations and ensure equality of access and pricing for the OLOs. This meant the charges paid by BT's Retail division and the OLOs for Openreach services would be the same without any cross-subsidy, prioritisation or preference to BT's operations. The creation of Openreach and the related equality of access conditions played a significant part in fuelling the competition for delivering broadband (Pemberton, 2012; Young, 2012). By 2009, TalkTalk, Virgin Media and BT Retail had almost similar market share within the retail broadband space with Sky also registering double digit market share [12]. The outcome was that the broadband tariffs continued to reduce in favour of the end-user [13] and provided further incentives to DSL broadband adopters. By this time, the near universal adoption of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 WiFi standards in devices such as laptops, mobile phones and customer premise equipments (CPEs) had made broadband adoption an easier and more attractive prospect for end-users. The improvements in the speeds delivered by the 802.11 standards and the increased availability of wireless connectivity via WiFi hotspots provided an important benefit for the growing number of end-users. The reliance of these WiFi hotspots on DSL broadband combined with the increased demand and competition was one of the factors that led to the introduction of ADSL2 and ADSL2+ products. Effectively, the average actual residential broadband speeds in the UK increased up to 7.6 Mbit/s by November 2011 (Ofcom, 2009; 2011; 2012a; Shearman, 2012; Young, 2012).

The impact of this race within the DSL broadband space was that the cable broadband adoption numbers lagged behind the DSL broadband numbers throughout this period [14]. With the cable industry focused on consolidation and integrating their operations, BT's introduction of DSL broadband via a registration scheme successfully overtook the

cable numbers by 2003-2004 (see note 14). Considering the near-ubiquitous reach of the copper PSTN, the availability of DSL broadband connections was also significantly higher than the cable broadband technology (see note 10). However, with the creation of Virgin Media, the threat from the cable industry became more credible (Cluny, 2012). Since then the increasing broadband speeds delivered by Virgin Media have led to additional investments in Very-high-bit-rate digital subscriber line (VDSL), Fibre-To-The-Cabinet (FTTC) and, potentially vectored VDSL deployment by BT and investments in ADSL2+ by the LLU operators (Clarkson, 2012; Ofcom, 2009). The next section discusses these events and the extent to which the relative success of DSL broadband was influenced by the bandwagon effect.

### **The bandwagon effect on the broadband race**

One of the problems faced by the telecom operators was that without a critical mass of end-users, broadband could not be delivered at prices comparable to the existing narrowband connections. Another difficulty faced by the operators was that of converting the existing narrowband end-users to sign up for broadband. This meant convincing the end-users of the superiority and advantages of the broadband connections offered by telecom or cable operators. Having realised the importance of broadband, Ofcom wanted to promote competition in the broadband market by enabling unbundling of local loop and allowing OLOs to deliver copper-DSL to end-users. It can be argued that BT's approach until this time had been cautious and effectively hedged on the basis of the volume of dial-up connections and a lack of clear demand for broadband at a higher price than dial-up (Pemberton, 2012). This is crucial in that although the end-users arguably wanted higher-speed, the extent to which they were willing to absorb the cost of copper DSL rollout and the higher monthly charges was uncertain. Thus BT's position depended on the justifiability of investments in the face of this uncertainty. Its solution was the ADSL registration scheme (described below) which eventually resulted in a rapid DSL rollout throughout the UK and left cable broadband adoption behind in its wake [15].

In particular, the bandwagon effect can be observed to be at work in relation to BT's rapid expansion of DSL capability into the exchanges. When BT launched the ADSL registration scheme, it was in part to justify the investment in DSL, gauge the demand for higher-speed and more expensive service (than dial-up), to enable a deployment

plan for BT's broadband products and position its response to BT shareholders and Oftel. As part of this ADSL registration scheme, subject to the cost of DSL deployment being viable, BT promised to rollout DSL equipment to exchanges in those areas which had achieved a minimum threshold of end-user registrations (Oftel, 2002b). The minimum threshold varied depending upon the size of the exchange and the area under consideration. Such a strategy was arguably in line with BT's traditionally cautious approach towards rolling out new technologies (Cioffi, 2011b) and in part influenced by the need to justify investments given its financial position in 2001. BT's approach also mirrors Rohlfs' (1974) argument about using community of interest groups to achieve maximum (equilibrium) demand despite small size of initial user set. Despite field-trials during the later 1990s, DSL was a relatively untested product in actual deployments and the speeds offered by copper varied significantly depending on the distance of the end-user from the exchange and the quality of the line. In the context of the 2000-2001 economic recession, a short-term benefit of DSL to the embattled telecommunications operators (including BT) was that it would allow higher speeds to be delivered without the significantly higher investments of fibre. The registration scheme proved that sufficient demand existed and once the rollouts began, the end-users signing up for the DSL product began to accumulate quickly (see note 14).

The initial DSL broadband product was costlier than the existing narrowband products [16]. However, the speed benefits of DSL broadband were significant [17]. In addition, unlike the narrowband connection, a DSL connection also allowed the telephone line to be available while the Internet was being used. It is arguable that the early adoption of DSL broadband was driven by both these advantages over the existing narrowband connections. Having managed to ascertain the demand for DSL, BT's push for installation of DSL equipment was also set apace by the goals set by its then chief executive Ben Verwaayen (BT, 2002; Valdar, 2012; Verwaayen, 2012). As a result, the uncertainty around the financial viability of broadband deployment was successfully over-ridden. These factors resulted in a positive supply-demand side equation in which the increasing number of end-user registration led to wider DSL broadband roll-out. The subsequent DSL roll-out in turn was spurred by the increased demand.

Such a situation demonstrates both the types of the bandwagon effect at work. The network externalities are evidenced by the increase in the end-user registrations (see note 14). It became obvious that the DSL rollout would indeed take place subject to

registered end-user interest and that it clearly delivered benefits over the existing narrowband connections. In consequence, the demand side of the bandwagon effect was firmly established [18]. On the other hand, the complementary bandwagon effects are evidenced by the extent to which better speeds and the ubiquity of WiFi accelerated the DSL broadband rollouts [19]. Each of these supply-side effects contributed to the increased availability of DSL broadband. This rollout was also aided by a supply-side push on BT's part in response to regulatory pressure, reduced margins on the telephony services revenues and the availability of BT wholesale DSL products. The reliance of the OLOs on the BT wholesale DSL product as a means of competing, pointed to BT's stranglehold on the broadband market. As a result, Oftel pursued unbundling and the functional separation of BT to promote more competition.

Throughout this period, the capability of the cable networks to offer higher speeds and the possibility of market loss kept the telecom operators motivated and resulted in deployments of ADSL and ADSL2+ by the LLU operators and BT (Clarkson, 2012; Young, 2012). The cable operators, in turn, needed to distinguish their services since the telephony services were mostly commoditised. Their reliance on the wholesale content from BSkyB meant that delivering higher-speed broadband was a potentially important revenue stream. With the purchase of Virgin Mobile and the final consolidation into the "Virgin Media" brand, the cable network could deliver potentially quadruple-play of services and allow Virgin Media to position itself as an end-to-end service provider instead of just being a television or telephony operator (Cluny, 2012). Thus, although the adoption of cable broadband lagged behind DSL broadband in the long run, the competitive threat of cable broadband was one of the key factors that influenced DSL broadband rollout and the bandwagon effect that accelerated it.

## **Conclusions**

Until the mid-1990s, broadband was mostly associated with the delivery of broadcast television and on-demand video. The communications industry's expectations centred on delivering premium content services over the networks and the innovation was driven by the projected demand for such services. These expectations about delivering video as a revenue stream are seen to persist until late 1990s. By 1999-2000, the demand for the Internet had become evident as witnessed by the dial-up adoption numbers. This opened up an unforeseen revenue opportunity for the communications industry. The



focus of delivering a broadband service shifted to delivering a high-speed connection to the Internet instead of delivering just television or video-on-demand.

The copper-based PSTN had significant limitations when it came to delivering a high-speed connection. The alternatives available for the fixed-line operators (including cable) were DSL, coaxial cable and optical fibre. In the short term, optical fibre was ruled out due to the costs involved and the fact that the financial resources available were limited. That left DSL and cable broadband as the options in contention. DSL allowed the telecom operators to deliver broadband by sweating the existing copper assets. While it cost significantly less compared to optical fibre, DSL still required an investment that a company like BT would need to justify to its shareholders and investors. Although some trials had been done with DSL technology, it remained an untested technology in terms of large field-deployments.

However, the early adoption of DSL broadband was not driven by pricing benefits but the advantages it offered over the prevalent narrowband market. The speed and convenience of broadband effectively meant that as the DSL rollout gathered momentum, the number of end-users jumping on the DSL bandwagon also increased in proportion. At the same time, due to the prevailing market and economic circumstances, cable broadband, a superior technology, lagged behind DSL broadband in end-user adoption.

The bandwagon effect propelled the subsequent DSL adoption due to the demand for better Internet speeds and was also aided significantly by the falling prices. Cable broadband, despite the head-start in end-user adoption, was plagued by legacy issues within the cable industry. Although the telecom operators were also faced with financial problems, the DSL broadband did not suffer from the problems of fragmentation and incompatible standards. This meant that the rollout of DSL equipment was easier to accomplish. The uncertainty and questions around return on DSL investment faced by BT were partly answered by the registration scheme which clearly demonstrated a demand for higher speeds. The subsequent reduction in prices can be attributed to a combination of the competitive threat from cable, regulatory pressure from Ofcom in the form of unbundling and the increased economies of scale due to the wider rollout of DSL equipment. The growth in end-user demand, increased rollout of DSL equipment and the introduction of next-generation DSL technologies that delivered higher speeds

were the benefits of the bandwagon effect. The growth in end-users and the impact on pricing of broadband connections being offered indicate the network externalities that drove the demand-side of the DSL bandwagon. On the other hand, the subsequent acceleration in the rollout of DSL equipment at the BT exchanges, increased speeds due to the push for ADSL2, ADSL2+ deployments by LLU operators, ubiquity of WiFi-capable devices and wider availability of WiFi hotspots illustrates the complementary bandwagon effects that influenced the supply-side of the DSL bandwagon.

That the bandwagon effect worked in DSL's favour was a result driven by the prevailing technical, regulatory and socio-economic factors. The commercial and political expediency of DSL was aided by the combined influence of such factors along with the benefits that increased with end-user adoption (thus echoing the premise of the bandwagon effect). In the UK, the bandwagon effect led to positive supply-demand equation between the end-users, the incumbent operator (BT), OLOs and the regulator (Ofcom & Oftel).

A critical catalyst for the acceleration of DSL broadband adoption was the unbundling initiatives and landmark agreement in 2006 that created Openreach. The arrangements for equality of access and transparent retail-wholesale pricing triggered by the functional separation of BT were unique in the telecommunications regulatory environment. Its influence on the outcome can be evidenced by the lowering of broadband tariffs and entry of LLU operators such as TalkTalk and Sky into the UK market. This particular regulatory intervention meant that Ofcom's goal of delivering the best price environment for the end-users (including wholesale customers such as OLOs that rented capacity from BT) and developing a competitively priced market was fulfilled for a short term. Effectively, the bandwagon effect worked in tandem with regulatory decisions, status of industry finances, commercial expediency and short-term technical benefits of DSL over optical fibre and the competition from cable and LLU operators. The combination of all these factors stimulated broadband deployment and adoption in the UK. As a result, although cable broadband had led in terms of end-user numbers and technical merits as of 2001, by the end of the 2000s, DSL broadband deployment and adoption was firmly in the lead.

## Notes

1 - As of November 2001, dial-up or narrowband access was defined as "speeds up to and including 128 kilobits per second (kbps)" (Of tel, 2001a, p. 3). Broadband was defined as "higher bandwidth, always-on services, offering data rates of 128 kbps and above." (Of tel, 2001a, p. 3). Although Of tel/Of com still defines broadband as minimum 128 kbit/s, in practice the minimum speeds delivered have risen to 2 Mbit/s (Of com, 2006; 2009).

2 - This paper uses the term bandwagon economics to denote the superset of ideas associated with the bandwagon effect, network externalities, complementary bandwagon effects and their influence on the economics of technology deployment and adoption.

3 - The November 2001 Of tel report estimates that there were over 400 ISPs operating in the UK. 80% of the online households and 63% of the Small & Medium Enterprises (SMEs) with Internet access relied on narrowband connections. With 10 million homes and 2 million SMEs using narrowband, the market was arguably saturated.

4 - Joseph Lechleider from Bellcore, proposed the use of ISDN's improved echo-cancelled 2B1Q line code for each of T1's two twisted pairs thus yielding a speed of 800 kbit/s per pair i.e. 1.6 Mbit/s in total. He termed this High-speed digital subscriber line (HDSL), generally considered the first variant of DSL. See (Cioffi, 2011a) for further details.

5 - The stated goal was for the "UK to have the most extensive and competitive broadband market in the G7 by 2005" (Of tel, 2001b, p. 3)

6 - The Independent Television Commission (ITC) Annual Report 1997 mentions that 124 franchise areas had been awarded by Cable Authority before 1991. In the same report, ITC mentions 39 additional franchises being advertised or licensed in 1997.

7 - BT's profits after tax for the financial year ending in 1992, 1993 and 1994 were £2.07bn, £1.24bn, £1.8bn respectively (BT, 1992; 1993b; 1994a).

8 - e.g. BT agreed to sell Airtel in Spain to Vodafone for £1.1 billion (BT, 2001b, p. 31). BT also sold its 34% stake in Sunrise communications in Switzerland to Tele Danmark for

the equivalent of £464 million in cash, realising a profit of over £400 million. (BT, 2001b, p. 10)

9 - The demerger was completed in November 2001 when mmO2 plc was created. The mobile services provided by mmO2 would be under the "O2" brand (Curwen, 2009). In 2005, Telefónica, the Spanish Telecommunications operator agreed to buy mmO2 and BT Group's mobile business in the Europe for £17.7 bn (Curwen, 2006).

10 - The cable network footprint mostly remained the same at 50% of the UK homes and businesses. On the other hand, the DSL broadband reach grew from 60% as of 2001 (OfTel, 2001a) to 99.7% of homes and businesses by 2006 (BT, 2006, p. 9)

11 - As of 2005, BT's portfolio of wholesale products accounted for 70% of the broadband connections (Ofcom, 2006, p. 146). In 2005, BT's share of the retail broadband market was 24%, the highest amongst all broadband providers (Ofcom, 2006, p. 147). In the retail segment, BT's nearest competitors were NTL and Telewest at 20% and 10% market share respectively (Ofcom, 2006, p. 147).

12 - In 2009, the market share in the retail broadband segment for BT, Virgin media, TalkTalk and Sky was 25.9%, 22.5%, 24.7% and 12.4% respectively (Ofcom, 2009).

13 - The average monthly cost of DSL for residential and small business end-users in November 2001 was £40 (OfTel, 2001a). The average monthly cost of DSL for residential and small business end-users in September 2003 was £22-£24 (OfTel, 2003). By 2012, when bundled with landline (excluding line rental) the monthly costs were as low as £6.49 depending on the contract length, speed and data usage (Ofcom, 2012a).

14 - As of December 2001, the numbers of end-users on cable broadband & DSL were 196,000 & 136,000 respectively (OfTel, 2002a). In July 2002, the number of end-users of cable broadband had risen to 419,000 compared to DSL which had 290,000 end-users (OfTel, 2002b, p. 1). By September 2003, this trend had reversed. The number of DSL end-users had nudged ahead (and have remained ahead) to 1,380,000 to that of 1,232,000 for cable broadband (OfTel, 2003). In Q1 2012, the number of residential and small business end-users on DSL (including BT, LLU & non-LLU) were 16,173,000 compared to 4,165,000 for cable (Ofcom, 2012b).

15 - More than 560,000 potential end-users registered for the BT ADSL registration scheme by September 2003 (Of tel, 2003). This indicated a potential 50% increase in the number of end-users. See note 14 for further details of the increase in the DSL numbers.

16 - In November 2001, the average monthly cost of DSL for residential and small business end-users was £40. Compared to this the average cost of a FRIACO-based, fully unmetered narrowband connection was only £12.99 – £14.99 (See Of tel, 2001a, pp. 4-7)

17 - The basic rate offered by modern narrowband connections was 64 kbit/s. With pure text transmission, a narrowband connection could deliver 320 kbit/s but with significant reduction in the web experience. DSL broadband connections were required to deliver minimum speeds of 128 kbit/s (Of tel, 2001a).

18 - The registrations started in June 2002 when the number of DSL end-users were 290,000 compared to 419,000 end-users for cable broadband (Of tel, 2002b). By September 2003, the scheme had received 560,000 registrations during which time the DSL end-users had increased to 1,380,000 (Of tel, 2003).

19 - At the start of the registration scheme, the number of UK households covered by DSL was 66% with 1115 exchanges being DSL-enabled (Of tel, 2002b). By September 2003, the availability of DSL had increased to 80% with 1708 exchanges being DSL-enabled (Of tel, 2003).

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## **Interviews**

Cioffi, J. (2011b), Interview with the author. Milton Keynes, 15 December

Clarkson, D. (2012), Interview with the author. London, 27 January

Cluny, J. (2012), Interview with the author. Milton Keynes, 19 April

Crowcroft, J. (2012), Interview with the author. Cambridge, 23 January

Feasey, R. (2012), Interview with the author. Milton Keynes, 26 April

O'Reilly, J. (2011), Interview with the author. Cranfield, 22 December

Pemberton, M. (2012), Interview with the author. London, 10 February

Shearman, P. (2012), Interview with the author. London, 9 February

Smale, T. (2012), Interview with the author. Milton Keynes, 11 April

Taylor, M. (2012), Interview with the author. London, 27 March

Valdar, A. (2012), Interview with the author. London, 18 April

Verwaayen, B. (2012), Interview with the author. Milton Keynes, 14 February

Young, G. (2012), Interview with the author. London, 01 February

### **Details about the interview participants**

<b>Name</b>	<b>Expertise and affiliation in the communications industry (at the time of the interview)</b>
John Cioffi	<ul style="list-style-type: none"><li>Responsible for Orthogonal Frequency Division Multiplexing (OFDM) based Discrete MultiTone (DMT) method being used in DSL that made DSL a practical</li></ul>

Name	Expertise and affiliation in the communications industry (at the time of the interview)
	<p>technology</p> <ul style="list-style-type: none"> <li>• Founder of Amati Communications Corporation (now part of Texas Instruments) that did pioneering work on the first functioning DSL modems</li> <li>• Spearheaded the development of xDSL technologies and related standards, the latest of which is Dynamic Spectrum Management (DSM)</li> </ul>
David Clarkson	<ul style="list-style-type: none"> <li>• Competition Policy Director, Ofcom</li> </ul>
John Cluny	<ul style="list-style-type: none"> <li>• A veteran of the UK communications industry</li> <li>• Regulatory economist with a focus on the cable industry</li> </ul>
Jon Crowcroft	<ul style="list-style-type: none"> <li>• Marconi Professor of Communications Systems in the Computer Lab, at the University of Cambridge</li> <li>• Member of Technical advisory board at Max Planck Institute for Software Systems (MPI SWS), Institutos Madrileños de Estudios Avanzados (IMDEA) Networks, Korea Advanced Institute of Science and Technology (KAIST), Onelab &amp; the Foundation for Information Policy Research Advisory Council</li> <li>• Former professor in the Department of Computer Science University College London (UCL)</li> </ul>
Richard Feasey	<ul style="list-style-type: none"> <li>• Public Policy Director at the Vodafone Group</li> <li>• A veteran of the communications industry with past stints at Ionica and in the cable industry.</li> </ul>
John O'Reilly	<ul style="list-style-type: none"> <li>• Vice-Chancellor of Cranfield University</li> <li>• Specialist advisor to the UK Government and the European Commission</li> <li>• Chairperson of UK's Network Interoperability Consultative Committee (NICC) for Ofcom and the telecommunications industry</li> <li>• Former Principal Research Fellow with BT</li> <li>• Former Chief Executive of the Engineering and Physical Sciences Research Council (EPSRC)</li> </ul>

Name	Expertise and affiliation in the communications industry (at the time of the interview)
	<ul style="list-style-type: none"> <li>• Former President of the Institution of Electrical Engineers (now the Institution of Engineering and Technology (IET))</li> </ul>
Mike Pemberton	<ul style="list-style-type: none"> <li>• Access network architect at Sky Network Services</li> </ul>
Peter Shearman	<ul style="list-style-type: none"> <li>• Head of Infrastructure Policy, Broadband Stakeholder Group (BSG)</li> </ul>
Trevor Smale	<ul style="list-style-type: none"> <li>• A veteran of the UK communications industry</li> <li>• Regulatory expert and advisor</li> <li>• Lengthy stints in NTL and now Virgin Media</li> </ul>
Malcolm Taylor	<ul style="list-style-type: none"> <li>• Former President of EuroDOCSIS</li> <li>• Former Director of regulatory and public policy at Telwest (later Virgin Media)</li> </ul>
Andy Valdar	<ul style="list-style-type: none"> <li>• Visiting professor in telecommunications strategy with the Dept. of Electronic &amp; Electrical engineering at UCL</li> <li>• 30 year tenure in BT where responsibilities ranged from network strategy and planning, international standards, technical aspects of regulation to product management and development</li> </ul>
Ben Verwaayen	<ul style="list-style-type: none"> <li>• Chief Executive Officer (CEO) of Alcatel-Lucent</li> <li>• Former Chief Executive of BT (2002-2008)</li> <li>• Former Vice Chairman of the Management Board at Lucent</li> <li>• Former President and Managing Director of PTT Telecom, a KPN (Koninklijke KPN N.V., originally Koninklijke PTT Nederland) subsidiary</li> </ul>
Gavin Young	<ul style="list-style-type: none"> <li>• Head of Strategy and Planning, Cable &amp; Wireless Worldwide</li> <li>• Advisor, Ofcom Spectrum Advisor Board (OSAB)</li> <li>• Former Board Director/Technical Chairman, Broadband Forum</li> </ul>